

**Cloud Retrievals in the Arctic –
A Few Preliminary Results for Liquid Water Clouds
from FIRE/ACE**

or

The Trouble with Sea Ice

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Outline:

- The FIRE/ACE experiment
- Liquid water cloud retrievals (τ , r_e) over ice/snow surfaces
- Snow/ice albedo and reflectance measurements in the Arctic
- Example MODIS Airborne Simulator (MAS) retrievals from FIRE/ACE

FIRE/ACE

First ISCCP (Internat. Satellite Cloud Climatology Project)
Regional Experiment / Arctic Cloud Experiment

Study radiative effects of clouds in vicinity of:

- Barrow AK
- Beaufort and Chuckchi seas
- Ice Station SHEBA (Surface HEat Budget of Arctic ocean) – research vessel adrift in pack ice

Platforms:

Remote Sensing:

NASA ER-2 (MAS, AMPR, HIS, ... – PM-1 like)

In Situ:

University of Washington CV-580, NCAR C-130Q

Surface:

SHEBA (NSF, ONR): radiation fluxes, radar,
microwave radiometer, lidar, ...

ARM (DOE, Atmospheric Radiation Measurement
program) – Barrow AK: similar to SHEBA

Usual Solar Reflectance Retrieval Approach

one non-absorbing band (0.67, 0.86, 1.2 μm)

$$R \bullet R(\tau)$$

+

one absorbing band (1.6, 2.2, 3.7 μm)

$$\text{droplet absorption} = 1 - \bar{\omega}_0 \sim r_e \Rightarrow R = R(\tau, r_e)$$

\Rightarrow simultaneous retrievals of cloud optical thickness (τ)
and effective radius (r_e)

**To minimize retrieval model error due to
sea-ice surface albedo, A_{sfc} :**

Need:

- A_{sfc} has to be known temporally, spatially
- Variability (small scale) in A_{sfc} should be small

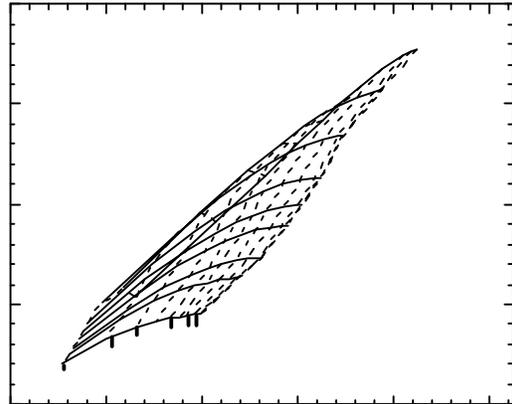
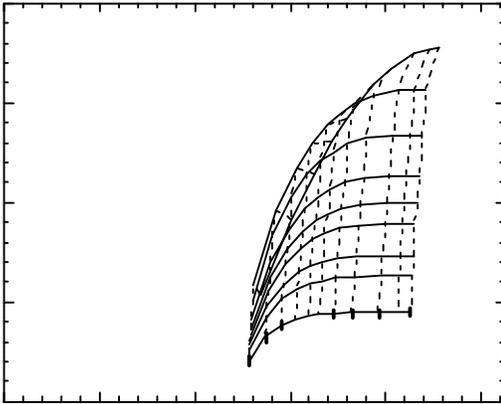
Bonus:

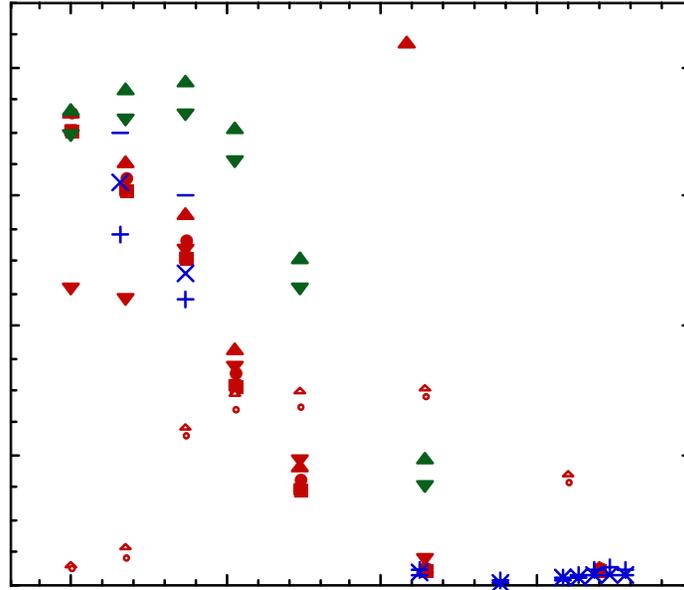
For regions containing both sea ice and open water, difficult to obtain high resolution surface information (other algorithms, ancillary data, etc.) when clouds are present \Rightarrow

- Desire difference in A_{sfc} between sea ice and open water to be small

**Possible alternative – use the 1.6 μm band as a surrogate
for the non-absorbing band in the retrieval?**

**Solution Space for Cloud Retrievals using
either the 0.67 and 1.6 μm bands in
conjunction with a 2.1 μm band**

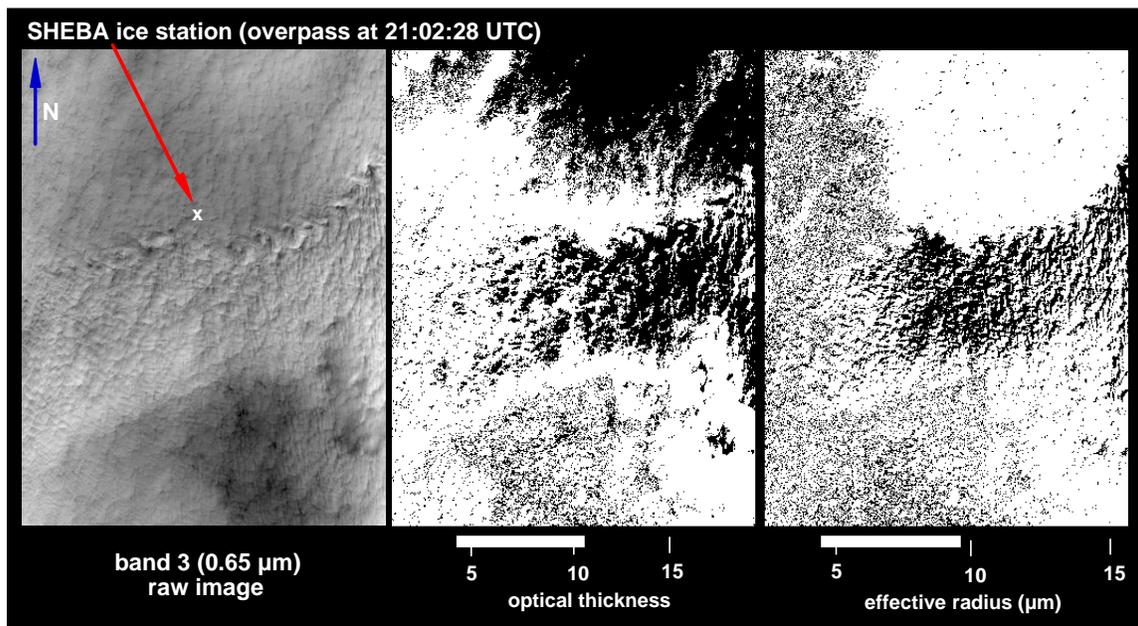




Summary of CAR spectral albedo measurements from two previous Arctic field experiments (ARMCAS and LEADEX). Also shown are selected MAS bidirectional reflectance observations from 29 May 1998 during FIRE/ACE.

FIRE/ACE cloud retrieval (using MAS bands 10 & 20)

3 June 98



Cloud retrieval for a mid level stratus cloud overlying sea ice on 3 June 1998 near the SHEBA Ice Station during FIRE-ACE. Cloud tops were at about 3.3 km.

3 June 1998

MAS retrieval summary and comparison with
UW CV-580 in situ measurements

Parameter	MAS retrievals* (pixel average, standard deviation)	UW CV-580 (profile)
τ	9.3	10.7 ¹
σ_{τ}	0.7	
r_e (μm)	7.7	8-9 ²
σ_{re}	0.7	
LWP (gm^{-2})	48	43 ³
σ_{LWP}	5.4	

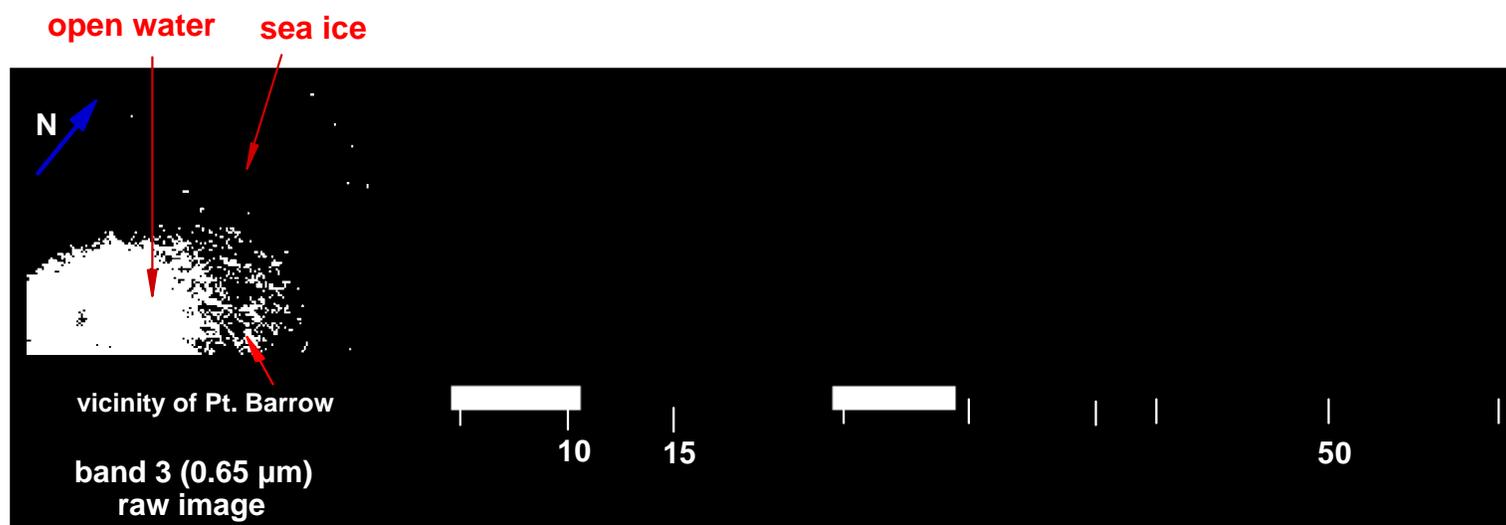
* using 1.6 μm and 2.1 μm MAS bands

¹ g-meter probe, Gerber Scientific (courtesy H. Gerber)

² FSSP, expected retrieval range with adiabatic vertical profile

³ PVM (w/calibration from H. Gerber)

FIRE/ACE cloud retrieval (using MAS bands 10 & 20) 6 June 1998



Cloud retrieval for a boundary layer stratus cloud overlying both bright sea ice surface and dark open water on 6 June 1998 just North of Barrow, AK during FIRE-ACE. The cloud deck was about 300 m thick with cloud tops at 900 m.

6 June 1998

MAS retrieval summary and comparison with
UW CV-580 in situ measurements:

Parameter	MAS retrievals[*] (pixel average, standard deviation)	UW CV-580 (profile)
τ	11.2	8.6 ¹
σ_{τ}	1.5	
r_e (μm)	9.4	9-10 ²
σ_{re}	1.0	
LWP (gm^{-2})	70	60 ³
σ_{LWP}	8	

^{*} *using 1.6 μm and 2.1 μm MAS bands*

¹ g-meter probe, Gerber Scientific (courtesy H. Gerber)

² FSSP, expected retrieval range with adiabatic vertical profile

³ PVM (w/calibration from H. Gerber)

Summary

- Cloud retrievals based on solar reflectance measurements traditionally have used VIS/NIR band + SWIR band to retrieve optical thickness and effective radius.
- Sea ice albedo in the VIS/NIR cloud retrieval bands (0.67, 0.86, 1.2 μm) is both large and highly variable – both combine to seriously impact retrieval uncertainty.
- Sea ice albedo in the SWIR bands is relatively small (comparable to dark open water during June) – little impact on retrieval uncertainty.
- A modified cloud retrieval algorithm has been developed which only uses the SWIR bands.
- Preliminary MAS retrievals during FIRE/ACE are in good agreement with in situ measurements.